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Title: LANL Environmental ALARA Program Status Report for CY 2014

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Intended for: Los Alamos Field Office, Environmental Projects

Los Alamos
NATIONAL LABORATORY
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LANL Environmental ALARA Program Status Report for CY 2014

Introduction

Los Alamos National Laboratory is committed to ensuring that radiation exposures of members of the public and the environment from LANL operations, past and present, are as low as reasonably achievable (ALARA). A Finding (RL.2-F-1) and Observation (RL.2-0-1) in the NNSA/ LASO report, *September 2007, Release of Property (Land) Containing Residual Radioactive Material Self-Assessment Report*, indicated that LANL had no policy or documented process in place for the release of property containing residual radioactive material. In response, LANL developed *PD410, Los Alamos National Laboratory Environmental ALARA Program.* This document was officially published as a Laboratory-wide policy and became effective on August 8, 2008 and was updated in 2011. The document provides program authorities, responsibilities, descriptions, processes, and thresholds for conducting qualitative and quantitative ALARA analyses for prospective and actual radiation exposures to the public and the environment from DOE activities conducted on site.

The document specifies requirements for reporting program status to NNSA/ Los Alamos Field Office:

> If the potential dose from a chosen ALARA alternative exceeds 10 mrem TEDE to any member of the public per year or a collective dose of 100 person-rem TEDE per year, the National Nuclear Security Administration/ Los Alamos Site Office (NNSA/LASO) will be notified in writing.
>
> In addition, a report summarizing the activities of the program is submitted to NNSA/ LASO for the previous calendar year no later than the end of the first quarter of the following year. This report describes any changes to the Laboratory Environmental ALARA Program, including organizational structure, responsibilities, and authorities. All environmental ALARA records for the previous calendar year generated as a result of implementing the program are submitted to the NNSA/ LASO as an appendix to the report. These records include letters, determinations, and analysis reports.

The remainder of this report provides the information specified above.

Exceedances of Potential Doses from ALARA Alternatives

During 2014, there were no potential doses determined through ALARA analysis alternatives that exceeded 10 mrem TEDE to any member of the public per year or a collective dose of 100 person-rem TEDE per year (LANL 2014).

Changes to the Program and Associated Documents

DOE O 458.1 was fully implemented by the Laboratory in November 2012. While no changes to the 458.1 ALARA program were made in 2014, an update to P412 "Environmental Radiation Protection" was made to reflect Change 3 in DOE O 458.1. These changes were editorial in nature.

Summary of Environmental ALARA Activities

One of primary methods of identifying new activities that could affect dose to the public and environment is through the Project Review and Requirements – Identification (PR-ID) system. During 2014, the Environmental Health Physics review became more formally integrated into the PR-ID review. Through the review process, multiple projects needing environmental health physics support were identified. These projects were primarily associated with release of personal and real property. The DOE Field office was engaged in many of these projects.

Specific activities included dose assessments and ALARA analyses that were performed for the conveyance of land under Public Law 105-119 in 2014. Sampling protocol using the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) was followed for statistical sampling and analysis for tracts A-5-2 and A-5-3 (Attachments 1 and 2), as outlined in DOE O 458.1. The potential radiation dose for recreational users in A-5-2 and A-5-3 were < 3 mrem/yr and considered ALARA (Attachments 1 and 2). Though these two tracts were not conveyed in 2014, each of these tracts were independently validated by the DOE Field Office and their contractor and are ready for transfer in 2015.

Regarding the release of personal property beyond that released under P121 and the occupational radiation protection program, materials and debris from buildings that were verified as non-radiologically impacted were released to the public through disposition in commercial landfills or for recycling in 2014. The buildings and structural materials were surveyed under The Multi-Agency Radiation Survey and Assessment for Materials and Equipment (MARSAME) protocol and released included buildings 27, 33, and 149 in TA-48 and buildings 8001, 42, and 387 in TA-21.

References

LANL 2014. Los Alamos National Laboratory 2013 Annual Site Environmental Report. Los Alamos National Laboratory Report LA-UR-14-27564. (http://permalink.lanl.gov/object/tr?what=info:lanl-repo/eprr/ERID-261879)

Records

Dose assessment of LANL-derived residual radionuclides in soils with Tract A-5-2 for land transfer decisions. Los Alamos National Laboratory Report LA-UR-14-26914.

Dose assessment of LANL-derived residual radionuclides in soils with Tract A-5-3 for land transfer decisions. Los Alamos National Laboratory Report LA-UR-14-26915.

Attachment 1

Dose Assessment of LANL-Derived Residual Radionuclides in Soils Within Tract A-5-2 for Land Transfer Decisions

August 2014

LA-UR-14-26914

1.0 Background for Tract A-18-a Dose Assessment[1]

1.1 Site Location

The A-5-2 Tract is located just north of the boundary of DP Mesa, Technical Area-21 (TA-21) and south of Highway 502 (Figure 1). This A-5-2 Tract is a revision of the original tract and now stops approximately at the northern boundary of the DP Canyon floodplain and extends from the A-10 tract downstream. The tract consists of the DP Canyon portion of the "Airport Tract" (DOE 1999). This tract contains undeveloped hillslope and canyon bottom accessed from DP Road. DP Canyon has an ephemeral stream and receives runoff from surrounding mesas and areas.

The area is primarily covered in piñon-juniper woodlands, which have experienced an extensive die-off since the Cerro Grande fire in 2000 and the Las Conchas fire in 2011, partly as a result of drought and subsequent bark beetle infestations. The tract contains sensitive wildlife habitat. Specifically, habitat for the Mexican Spotted Owl overlaps this tract, and parts of the tract are foraging habitat for the bald eagle. Noise in the vicinity of this tract comes primarily from motor vehicles traveling along State Highway 502. There is a negligible amount of night-shine from the artificial light sources on the mesa top to the west.

1.2 Sampling and Analysis Plan

The Sampling and Analysis Plan (SAP) for Tract A-5-2 (Appendix A) was developed using a MARSSIM (MARSSIM 2000) approach, as required in DOE Order 458.1 and LANL procedures (LANL 2012b, c). The objective of the SAP was to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in soils in Tract A-5-2 are documented, in appropriate units, and are below the 15 mrem yr^{-1} Screening Action Levels (SALs), as derived in LANL (2012a). The SAP for Tract A-5-2 followed the LANL (2012b) procedure EDA-QP-238, "Dose Assessment Data Quality Objectives for Land Transfers into the Public Domain." The coordinates for the sampling locations are provided in Table 1.

1.2.1 Preliminary Results from Surveys for Residual Contamination

As detailed in the SAP for Tract A-5-2 (Appendix A), previous measurements of soil concentrations were used as preliminary data to determine the potential for soil contamination in the tract and the standard deviation was used in the Sign Test to determine the number of samples required in the final survey of Tract A-5-2, as outlined in MARSSIM.

The preliminary analysis showed soil concentrations were below residential and recreational SALs, but elevated above background in some cases, though some of the samples were collected in the floodplain sediment where radionuclide concentrations could be expected to be higher relative to hillslopes (see Appendix A, Table 1). This preliminary data set suggested that the tract met the criteria for a Class 3 area under MARSSIM (potentially impacted by LANL operations, but the soil concentrations are expected to be near background levels and far lower than the SALs). Additionally, walk-over gamma surveys show Cs-137 from past contamination spills is

[1] Portions of Sections 1.1, to 1.4.1 in the Background Section were directly imported into this document from the Environmental Baseline Survey (Pope et al. 2008) with slight formatting modifications.

largely confined to stream sediment and does not spread upslope into Tract A-5-2 (Gaul 2014). Given this data, the A-5-2 tract was designated as a Class 3 Area under MARSSIM and the expected land use is recreational use (e.g., hiking, biking). The sampling locations in both portions were randomly selected and are more representative of hillslope soil concentrations. Surface soils (0 -1 ft) were collected at each location. Details are provided in the SAP (Appendix A).

1.3 Statistical Analysis

The principle study question was: Does the residual radioactive contamination exceed Authorized Limits (ALs), individually or collectively, for the recreational exposure scenario?

The decision alternatives were:

- If results from the soil radioactive contamination measurements are at or above the AL (collectively), the site is not a candidate for land transfer.
- If results from the soil radioactive contamination measurements are below the AL (collectively), the site is a candidate for land transfer.

The decision rule was based on the null hypothesis that the mean residual contamination levels in soil and/or sediment in Tract A-5-2, individually or combined over all radionuclides, are above the ALs and likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment in Tract A-5-2, individually or combined over all radionuclides, is below the AL and unlikely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}.

The assumed future land use and exposure pathway assumes recreational use for tract A-5-2. The radionuclides analyzed for and the respective recreational ALs are provided in Table 3. The 15 mrem yr^{-1} ALs used in this analysis were calculated using RESRAD (RESRAD 2001), as documented in LANL (2012a).

1.3.1 Statistical Evaluation of the Survey Results

All the applicable data that has passed the Measurement Quality Objective (MQO) evaluation will be used to determine the upper-bound confidence level (UCL) estimate of the mean for soil concentrations (generally, the 95 percent value) for each radionuclide. The EPA software ProUCL (EPA 2010) was used to determine the UCLs. The analyses were done at an independent laboratory and all passed requisite DQOs, as required for the comparisons to the ALs.

The statistical decisions as to whether the residual soil contamination levels (i.e., the 95 percent UCLs) were below the authorized limits were evaluated using the following criteria.

Decision Criteria:

1) If all samples are ≤ recreational ALs, then no further action is required and the site passes the criteria for recreational use. No further actions are needed.
2) If all samples or the UCL are > the AL, then the site is not a candidate for release and site remediation is needed followed by resampling before it can be released.
3) If the UCL is below the AL but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to

evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background or very low relative to the AL, use the Sign Test. For Tract A-5-2, the Sign Test will be used with a $p < 0.05$ decision threshold for significance. See MARSSIM chapter 8 for details and examples.

4) Because of multiple radionuclides, we also tested that the ratio of the upper-confidence level (UCL) of the average concentration divided by the AL and the sum of the ratios did not exceed 1, as show in eqn. 1. Because there was no indication or reasonable physical mechanism to create hot spots, we assumed that the contamination was homogeneously distributed across the tract.

$$\sum_{i-1}^{n} \frac{\overline{C}_{UCL,i}}{C_{AL}} \leq 1 \qquad \text{(eqn.1)}$$

Here $\overline{C}_{UCL}$ is the 95 percent upper bound estimate of the concentration mean, C_{AL} is the recreational AL (15 mrem yr^{-1}).

1.3.2 ALARA Evaluation

LANL policy P410 “Los Alamos National Laboratory Environmental ALARA Program” (LANL 2011) requires an ALARA evaluation based on procedure SOP-5254 “Performing ALARA Analysis for Public Exposures” (LANL 2009b). If the calculated individual dose exceeds 3 mrem yr^{-1}, then a quantitative ALARA evaluation is performed.

1.4 Instrumentation and Measurement Quality Objectives

The main objectives are to determine an appropriate analysis technique for each radionuclide and ensure Measurement Quality Objectives (MQOs) are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

1.4.1 Measurement Quality Objectives:

- Detection Capability: Minimum Detection Concentration (MDC) should be below the MARSSIM defined Lower Bound of the Gray Region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported and the level reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.
- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.
- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements. However, in this case, all samples will be analyzed in the laboratory.

2.0 Results and Analyses of Measurements

Table 2 provides the individual measurements of soil concentrations for the randomly selected locations. Averages, standard deviations, 95 percent UCLs, and ALs for each of the radionuclides are provided in Table 3. Results show that all radionuclide concentrations were significantly below the ALs and meet the real property release criteria for recreational use. Combining all radionuclides by using Eqn. 1, the sum of the ratios of the 95 percent UCL without background subtraction divided by the ALs was 0.13 mrem yr^{-1}.

2.1 ALARA Analysis

Tables 3 shows that the estimated dose was 0.13 mrem yr^{-1}. Because this dose does not exceed the threshold of 3 mrem yr^{-1} for performing a quantitative ALARA analysis, no further ALARA analysis is required in accordance with PD410, Los Alamos National Laboratory Environmental ALARA Program, and the calculated dose of 0.13 mrem yr^{-1} is therefore considered ALARA.

2.2 Quality Assurance

Soils were collected according to procedures and the laboratory analysis techniques were appropriate for the specific radionuclides, as required in the SAP for A-5-2 (Appendix A). The analysis at the independent laboratory was within their predefined boundaries and met all quality assurance requirements. Only qualified data was used in this analysis and minimum detectable concentrations were below the LBGR. Thus, all measurement quality objectives were met for this data set.

2.3 Conclusion

Given that 1) all the measurements (randomly selected hillslope and sediment samples in the floodplain) were below the ALs for each individual radionuclide, 2) the sum of the ratios was below 1, and 3) the resulting combined calculated dose was less than the 15 mrem yr^{-1} for a hypothetical recreational user, we conclude that Tract A-5-2 is a candidate for conveyance to the public for recreational use. Additionally, the soil concentrations of any residual radioactive contamination in both portions of A-5-2 are significantly lower than ALs for construction workers and we found no evidence of pockets of contamination. Thus, it is likely that potential doses resulting from other short-term (e.g., <1mo) construction-like or maintenance activities within the tract such as trenching, fence installation, digging, etc. would likely meet the dose criteria objectives and not require dose assessment. Specific sampling and dose assessments can be done for more involved work if there are concerns of dose for specific jobs performed within the tract.

3.0 REFERENCES

EPA (Environmental Protection Agency), 2010. ProUCL Version 4.1 User Guide (draft). EPA/600/R-07/041.

Gaul, W., 2014. Correlating counts per minute to pCi/g in Tract A-5-2 for sources of 137Cs in soil at Los Alamos New Mexico, Rev 1. Consultant report: Tidewater Inc.

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Figure 1. Sampling locations (yellow dots) are shown within Tract A-5-2 (boundary in green). Highway 502 and Los Alamos County airport are just north of the tract. Red dots are sampling locations in neighboring Tract A-5-3.

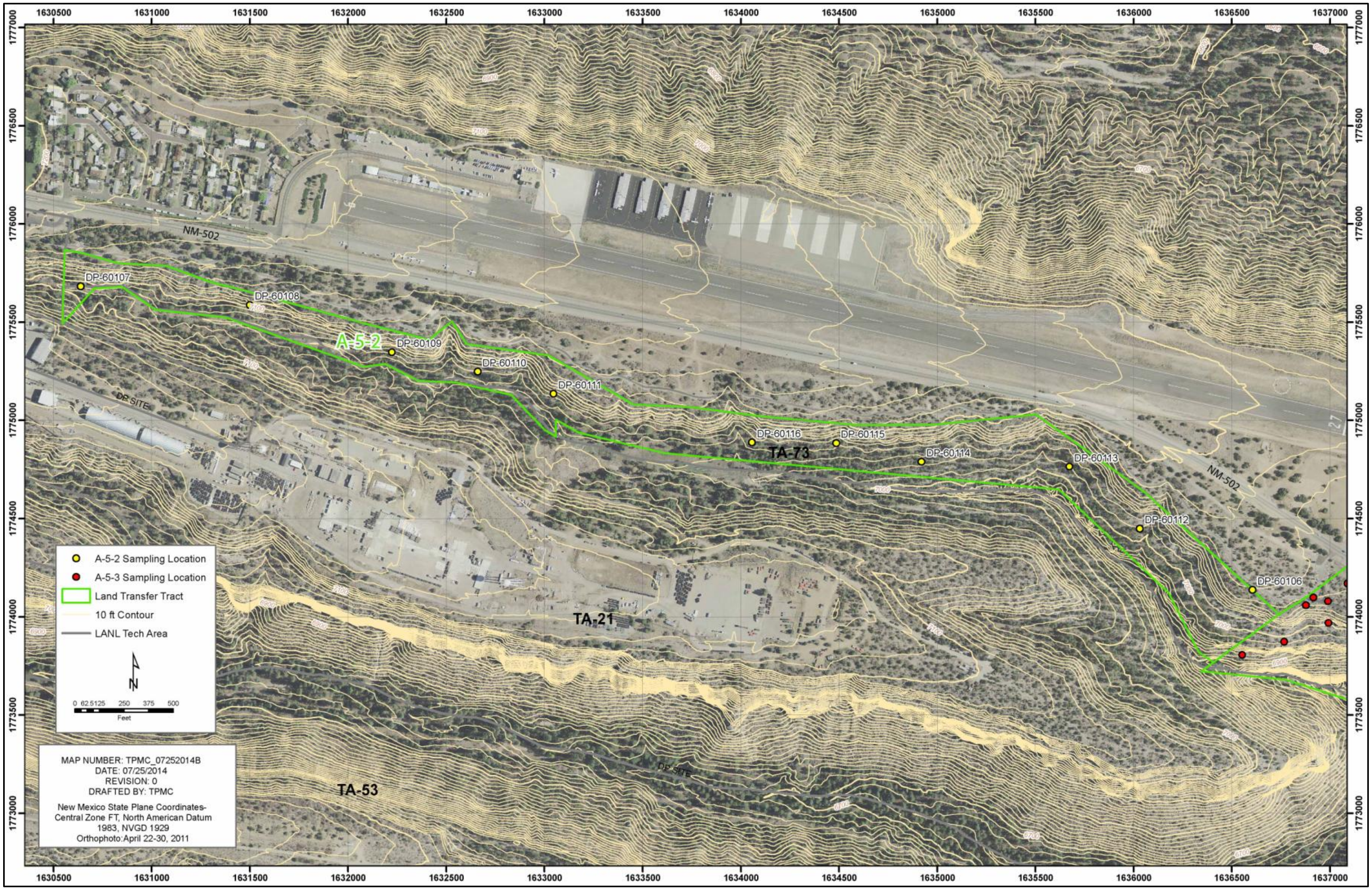

Table 1. Coordinates for randomly selected sample locations shown in Figure 1.

Location ID	Depth (ft bgs)[b]	Northing (ft) [c]	Easting (ft) [c]	Comments
DP-60106	0–0.5	1774136.527	1636606.338	Proposed sampling location moved approximately 30 ft south into Tract A-5-2
DP-60107	0–1	1775682.630	1630638.543	—[d]
DP-60108	0–1	1775587.550	1631500.207	—
DP-60109	0–1	1775346.284	1632224.005	—
DP-60110	0–1	1775247.639	1632660.185	—
DP-60111	0–1	1775135.037	1633046.542	Proposed sampling location moved approximately 20 ft south to avoid cliff
DP-60112	0–0.5	1774448.965	1636031.965	—
DP-60113	0–0.25	1774763.256	1635673.474	Proposed sampling location moved approximately 20 ft northeast to avoid exposed bedrock
DP-60114	0–0.25	1774788.877	1634920.716	—
DP-60115	0–1	1774883.957	1634485.724	—
DP-60116	0–1	1774887.523	1634057.863	—
DP-60106	0–0.5	1774136.527	1636606.338	Field duplicate of sample CADP-14-81397
DP-60111	0–1	1775135.037	1633046.542	Field duplicate of sample CADP-14-81402

[a] All samples analyzed for Americium-241, Isotopic Plutonium, Isotopic Uranium, Gamma Spectroscopy, Strontium-90, and Tritium

[b] Sample depths less than1 ft bgs indicate refusal at bedrock contact

[c] SPCS New Mexico Central Zone, Feet, NAD83

[d] — No comment

Table 2. Results from soil sampling in Tract A-5-2. Sampling locations are provided in Figure 1.

Sample Locations	Radionuclide	Concentration (pCi/g)	1 STD (pCi/g)	MDA (pCi/g)
DP-60106	Americium-241	0.352	0.035	0.026
DP-60107	Americium-241	0.027	0.009	0.007
DP-60108	Americium-241	0.43	0.039	0.015
DP-60109	Americium-241	0.272	0.029	0.014
DP-60110	Americium-241	0.289	0.03	0.019
DP-60111	Americium-241	0.173	0.023	0.026
DP-60112	Americium-241	0.219	0.025	0.014
DP-60115	Americium-241	0.065	0.014	0.031
DP-60116	Americium-241	0.098	0.018	0.031
DP-60113	Americium-241	0.087	0.014	0.017
DP-60114	Americium-241	0.009	0.004	0.012
DP-60111	Cesium-137	0.436	0.044	0.066
DP-60112	Cesium-137	0.545	0.046	0.058
DP-60113	Cesium-137	1.216	0.076	0.08
DP-60114	Cesium-137	0.4	0.043	0.07
DP-60115	Cesium-137	0.343	0.042	0.073
DP-60106	Cesium-137	0.24	0.054	0.098
DP-60107	Cesium-137	0.018	0.023	0.076
DP-60108	Cesium-137	0.89	0.072	0.093
DP-60109	Cesium-137	-0.001	0.017	0.091
DP-60110	Cesium-137	0.379	0.04	0.055
DP-60116	Cesium-137	0.608	0.052	0.064
DP-60111	Cobalt-60	0.002	0.023	0.082
DP-60112	Cobalt-60	-0.013	0.033	0.087
DP-60113	Cobalt-60	-0.003	0.289	0.09
DP-60114	Cobalt-60	-0.016	0.031	0.078
DP-60115	Cobalt-60	0	0.042	0.147
DP-60106	Cobalt-60	-0.019	0.035	0.121
DP-60107	Cobalt-60	-0.007	0.038	0.077
DP-60108	Cobalt-60	0.01	0.027	0.095
DP-60109	Cobalt-60	-0.002	0.366	0.082
DP-60110	Cobalt-60	-0.002	0.028	0.1
DP-60116	Cobalt-60	0	0.018	0.067
DP-60106	Plutonium-238	0.015	0.012	0.039
DP-60107	Plutonium-238	0.019	0.006	0.006
DP-60108	Plutonium-238	0.022	0.009	0.02
DP-60109	Plutonium-238	0.033	0.01	0.018
DP-60110	Plutonium-238	0.017	0.008	0.023
DP-60111	Plutonium-238	0.022	0.011	0.034
DP-60112	Plutonium-238	0.005	0.005	0.019
DP-60113	Plutonium-238	0.023	0.008	0.007

DP-60114	Plutonium-238	0.042	0.011	0.007
DP-60115	Plutonium-238	0.005	0.01	0.039
DP-60116	Plutonium-238	0.011	0.01	0.033
DP-60106	Plutonium-239/240	0.036	0.012	0.028
DP-60107	Plutonium-239/240	0.526	0.047	0.022
DP-60108	Plutonium-239/240	0.123	0.02	0.007
DP-60109	Plutonium-239/240	5.052	0.33	0.026
DP-60110	Plutonium-239/240	0.792	0.066	0.027
DP-60111	Plutonium-239/240	1.327	0.102	0.026
DP-60112	Plutonium-239/240	0.099	0.018	0.024
DP-60113	Plutonium-239/240	0.276	0.032	0.019
DP-60114	Plutonium-239/240	0.254	0.03	0.019
DP-60115	Plutonium-239/240	0.308	0.035	0.039
DP-60116	Plutonium-239/240	1.282	0.099	0.033
DP-60106	Strontium-90	0.054	0.153	0.262
DP-60107	Strontium-90	0.138	0.135	0.215
DP-60108	Strontium-90	0.171	0.18	0.29
DP-60109	Strontium-90	0.128	0.151	0.245
DP-60110	Strontium-90	0.215	0.139	0.208
DP-60111	Strontium-90	0.216	0.181	0.281
DP-60112	Strontium-90	0.106	0.145	0.238
DP-60113	Strontium-90	0.217	0.145	0.217
DP-60114	Strontium-90	0.077	0.149	0.25
DP-60115	Strontium-90	0.494	0.216	0.291
DP-60116	Strontium-90	0.199	0.137	0.207
DP-60106	Tritium	-1.386	0.388	1.331
DP-60107	Tritium	-1.115	0.378	1.293
DP-60108	Tritium	-0.06	0.376	1.262
DP-60109	Tritium	0.219	0.323	1.073
DP-60110	Tritium	0.596	0.362	1.185
DP-60111	Tritium	0.616	0.322	1.05
DP-60112	Tritium	-0.136	0.307	1.034
DP-60113	Tritium	0.081	0.338	1.13
DP-60114	Tritium	0.249	0.299	0.992
DP-60115	Tritium	0.427	0.338	1.115
DP-60116	Tritium	0.693	0.355	1.158
DP-60106	Uranium-234	0.86	0.073	0.063
DP-60107	Uranium-234	1.445	0.102	0.029
DP-60108	Uranium-234	0.688	0.056	0.023
DP-60109	Uranium-234	1.298	0.094	0.03
DP-60110	Uranium-234	0.905	0.069	0.03
DP-60111	Uranium-234	0.964	0.073	0.042
DP-60112	Uranium-234	0.712	0.061	0.052
DP-60113	Uranium-234	0.756	0.057	0.016
DP-60114	Uranium-234	1.141	0.087	0.036
DP-60115	Uranium-234	0.975	0.095	0.064

DP-60116	Uranium-234	1.064	0.081	0.016
DP-60106	Uranium-235/236	0.049	0.013	0.008
DP-60107	Uranium-235/236	0.089	0.015	0.018
DP-60108	Uranium-235/236	0.033	0.011	0.029
DP-60109	Uranium-235/236	0.046	0.012	0.028
DP-60110	Uranium-235/236	0.028	0.008	0.017
DP-60111	Uranium-235/236	0.033	0.01	0.019
DP-60112	Uranium-235/236	0.029	0.009	0.007
DP-60113	Uranium-235/236	0.014	0.006	0.017
DP-60114	Uranium-235/236	0.03	0.01	0.018
DP-60115	Uranium-235/236	0.042	0.022	0.066
DP-60116	Uranium-235/236	0.044	0.011	0.007
DP-60106	Uranium-238	0.905	0.074	0.028
DP-60107	Uranium-238	1.623	0.113	0.033
DP-60108	Uranium-238	0.653	0.054	0.027
DP-60109	Uranium-238	1.226	0.09	0.036
DP-60110	Uranium-238	0.978	0.073	0.032
DP-60111	Uranium-238	1.041	0.078	0.043
DP-60112	Uranium-238	0.823	0.068	0.055
DP-60113	Uranium-238	0.808	0.061	0.028
DP-60114	Uranium-238	1.189	0.09	0.043
DP-60115	Uranium-238	0.949	0.093	0.063
DP-60116	Uranium-238	1.09	0.083	0.02

Table 3. Statistical summary table for A-5-2 soil concentrations from data in Table 2. Soil background values (Ryti et al. 1998) are provided for comparison and dose calculations are shown for the recreational exposure scenario.

	Am-241	Cs-137	Co-60	Pu-238	Pu-239	Sr-90	H-3	U-234	U-235	U-238
Mean	0.184	0.461	-0.005	0.019	0.916	0.002	0.183	0.017	0.983	0.040
STD	0.140	0.356	0.009	0.011	1.444	0.018	0.118	0.685	0.240	0.019
Max	0.430	1.216	0.010	0.042	5.052	0.037	0.494	0.693	1.445	0.089
min	0.009	-0.001	-0.019	0.005	0.036	-0.026	0.054	-1.386	0.688	0.014
95% UCL	0.260	0.660	0.000	0.026	2.043	0.012	0.260	0.917	1.114	0.052
Background	0.006	0.420		0.005	0.015	0.360	0.130	1.400	0.087	1.220
Recreational SAL	890	210	46	850	770	3200	4.30E+05	2300	570	1700
Dose (mrem/yr)	4.38E-03	4.71E-02	3.91E-05	4.50E-04	3.98E-02	5.44E-05	9.07E-06	5.98E-03	2.93E-02	4.57E-04
Summed dose	1.28E-01									

APPENDIX A

Sampling and Analysis Plan for Tract A-5-2

1.0 Background for A-5-2

1.1 Site Location

The A-5-2 Tract is located just west of the eastern boundary of DP Mesa, Technical Area-21 (TA-21) and south of Highway 502 (Figure 1). This A-5-2 Tract is a revision of the original tract and now stops approximately at the northern boundary of the DP Canyon floodplain an extends from the A-10 tract downstream. The tract consists of the DP Canyon portion of the "Airport Tract" (DOE 1999). This tract contains undeveloped hillslope and canyon bottom accessed from DP Road. Vegetation includes ponderosa and piñon-juniper woodlands with open shrub, grasslands, and wildflower areas; A-5-2 is considered potentially sensitive wildlife habitat. DP Canyon has an ephemeral stream and receives runoff from surrounding mesas and areas.

1.2 General History

Historical maps from the pre-LANL era (1924), aerial photographs (1935), and historical accounts of life in the area show little development prior to LANL occupancy (pre World War II). Detroit businessman Ashley Pond started the "Los Alamos Ranch School" in 1917. The school began with a few ranch buildings from the Harold H. Brook homestead.

Laboratory operations began on nearby DP Mesa, just south of Tract A-5-2, in the late 1940s. Plutonium processing operations were conducted on DP Mesa in Tract A-16 in the technical area TA-21. Additionally, waste disposal operations were conducted at what is now designated Material Disposal Area B (MDA B) on the mesa-top in the western portion of Tract A-16. Tract A-5-2 has remained vacant throughout.

There are no Potential Release Sites (PRSs) located on the A-5-2 tract, but there are several PRSs that are associated with the historical Laboratory operations on adjacent lands.

1.3 Current Use

Tract A-5-2 is unoccupied, vacant land. No structures or facilities associated with LANL's federal, state, or local permits (such as air monitoring stations, radiation monitoring stations, or wastewater discharge outfalls) are located within the tract. The tract was never actively used by the Laboratory, no Laboratory operations were conducted within the tract boundaries, and no Laboratory structures were situated within the tract.

1.4 Summary of Historical Evaluation of LANL Impact

There are records of radioactive materials being spilled into the canyon bottom (Cs-137 and Sr-90 and Am-241) and air fall from historical operations at TA-21, southeast of this tract, and stack emissions from TA-1 may have resulted in surface deposition of radionuclides, particularly plutonium.

Tract A-5-2 does not meet the CERCLA 120(h) "uncontaminated" definition, even though DOE/NNSA and LANL believe all remedial actions necessary to address the known contamination on this tract, and allow its unrestricted transfer, have been completed according to the requirements of PL 105-119. Because the tract is not "uncontaminated," CERCLA Section 120(h)(4) is not applicable.

1.4.1 Adjacent Properties with Known or Suspected Releases

SWMU 21-029 and Consolidated Unit 21-021-99 are located immediately west of the A-5-2 tract. The remainder of the DP Canyon PRS, AOC C-00-021 is located directly west (upgradient) of the A-5-2 tract. See Appendix C in Swanton et al. (2006) for the history of use, site investigation and remediation activities, and current regulatory status of the PRSs in this tract.

SWMU 21-011(k) is an outfall that discharged into the south side of DP Canyon resulting in primarily Cs-137, Sr-90 and Am-241 soil contamination. This contamination is mainly confined to SWMU-21-011(k) and in downstream sediments within the floodplain. Both the DP Canyon floodplain and SWMU 21-029 are adjacent to A-5-2 along the southern boundary (Figure 2), and the radionuclide concentrations of these soils are lower than limits for recreational use (LANL 2004).

1.5 Preliminary Results from Surveys for Residual Contamination

Preliminary data was taken from soil surface samples collected in Tract A-5-2. Figure 2 shows the sample locations used in this analysis, and Table 1 provides the measured soil concentrations for the primary radionuclides of interest. The summary statistics in Table 1 show that the soil concentrations are at nominal background levels except for Pu-238 and Pu-239. Comparisons of soil concentrations show that all radionuclide concentrations are several orders of magnitude below the recreational use and the construction worker SALs (Table 1).

1.6 Conclusions regarding the classification of Tract A-5-2 relative to potential for residual radioactive contamination

There are properties adjacent or near to Tract A-5-2 that are either contaminated or have emitted radionuclides historically, and the preliminary data suggest LANL impact. Thus, residual contamination may exist on A-5-2 that was deposited from activities conducted by neighboring LANL operations from the late 1940s through the 2000s. However, the soil concentrations of radionuclides in soil from the preliminary set of measurements suggest that general levels are likely to be substantially below all SALs for recreational use and near background levels. Thus, DOE/NNSA believes no additional remedial activities are needed on the A-5-2 tract. Based on this assessment, the A-5-2 tract qualifies as a Class 3 area under MARSSIM (i.e., potentially impacted with concentrations of residual radioactive material in soils elevated, but likely to be below thresholds for the intended land uses and close to background levels (MARSSIM 2000). The Class 3 designation is modified further by the projected recreational land use. Regarding the recreational use designation, the exposure scenario would be for use of the entire tract for periodic recreation (hiking, biking, etc.) and the decision area would be the entire tract. If future use designation changes in these areas, to industrial use, for example, sampling plans for specifically identified areas of construction could be considered.

2.0 Data Quality Objectives for Sampling and Analysis Plan

The sampling and analysis plans (SAPs) for Tract A-5-2 follows the LANL (2012b) procedure EDA-QP-238, "Dose assessment data quality objectives for land transfers into the public domain."

2.1 Objective of the SAP

The objective of this sampling and analysis plan is to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in soils in the tract A-5-2 is documented, in appropriate units, and is below the 15 mrem yr^{-1} for public recreational use. The Screening Action Levels (SALs), as derived in LANL (2012) for a recreational scenario are provided in Table 1. **This and other SALs are used by LANL as preapproved Authorization Limits (ALs), as required in DOE Order 458.1 (section 2.k.(6)(f)2 in the contractors Requirements Document), and are identified as ALs in the rest of this SAP with regards to statistical decisions.**

2.2 Decision identification

The principle study question is: Does the residual radioactive contamination exceed ALs for the recreational exposure scenario in the area within A-5-2? The decision alternatives are:

- If results from the soil radioactive contamination measurements are at or above the AL (collectively), the site is not a candidate for land transfer.
- If results from the soil radioactive contamination measurements are below the AL (collectively), the site is a candidate for land transfer.

2.3 Inputs into the Decision

The assumed near-term future land use and exposure pathway assumes recreational use. ALs used for all the radionuclides analyzed for and the respective SALs are provided in Table 1 and the derivation of the SALs is provided in LANL (2012). The 15 mrem yr^{-1} SALs used in this analysis were calculated using RESRAD (RESRAD 2001) and documented in LANL (2012).

Data to be used in the analysis include preliminary surface soil concentration measurements (see Figure 2 for locations and Table 1 for the data used).

The unity rule will be applied because there are multiple radionuclides in the analysis. The formula used in for the unity rule is:

$$\frac{C_1}{AL_1} + \frac{C_2}{AL_2} + \frac{C_3}{AL_3} \dots \dots . \frac{C_n}{AL_n} \leq \mathbf{1} \qquad \text{(eqn. 1)}$$

where $C_{1\text{-}n}$ and $AL_{1\text{-}n}$ are the upper-bound estimates of the mean concentrations for radionuclides (e.g., upper 95% values) and Authorized Levels 1 through n, respectively.

2.4 Study Boundaries

The study is limited to Tract A-5-2, as identified in Figure 1. As concluded from historical information and previous sediment sampling, the list of radionuclides in the analysis include Am-241, Cs-137, Co-60, H-3, Pu-238, Pu-239, Sr-90, U-234, U-235, and U-238. Individual doses are evaluated out to 1000 years.

2.5 Decision Rule

The decision rule is based on the null hypothesis that the mean residual contamination levels in soil and/or sediment in Tract A-5-2 combined over all radionuclides is above the AL and likely to result in an all-pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment in Tract A-5-2 combined over all radionuclides is below the AL and not likely to result in an all-pathway radiation dose to the critical receptor above 15 mrem yr^{-1}.

2.6 Limits on Decision Errors

The acceptable statistical errors for this analysis are that Type I error (i.e., conclude contamination levels at site are < AL when in fact it is > AL) has a probability of $p < 0.05$; and the Type II error is (i.e., conclude soil contamination level is > AL when in fact it is < AL) has a probability of $p < 0.1$. Normality of the distribution for the preliminary data is not assumed.

2.7 Optimization of Design Process

The survey design is optimized by analyzing historical information data. Specifically, there is no evidence of radiological operations within Tract A-5-2, but the preliminary data suggest there is evidence of impact from surrounding LANL operations though the soil concentrations are expected to be substantially lower than the SALs. Thus, the entire tract will be treated as a Class 3 area optimizing the number of required sample locations based on recreational land use. If land use requirements change in the future, sampling could be targeted to the specific area of the proposed activity, depending on the specifics of the activity.

2.8 Statistically-Based Evaluation for Number of Samples Required using MARSSIM

Google Earth was used to download a map of the Tract A-5-2 area, which was then incorporated into Visual Sampling Plan (VSP) software (Matzke et al. 2010). The approximate boundary of the tract was then delineated as a sampling area (Figure 3). The MARSSIM application within VSP was then used to determine the statistically-based sampling plan. The preliminary sampling data in Table 1 was used to determine the standard deviations needed for calculating the needed number of samples for each of the identified radionuclides. All sampling locations were randomly determined.

2.9 Instrumentation and Measurement Quality Objectives

The main objectives are to determine appropriate analysis techniques for each radionuclide and ensure Measurement Quality Objectives are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

2.9.1 Measurement Quality Objectives:

- Detection Capability: Minimum Detection Concentration (MDC) should be below the MARSSIM defined Lower Bound of the Gray Region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported and the level should be reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.
- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.
- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements. However, in this case, all samples will be analyzed in the laboratory.

2.9.2 Procedures used to meet these measurement quality objectives:

1) Collection of valid soil sample appropriate for the dose assessment,
    a. Sampling of soil will be done using LANL (2012a) procedure SOP-5132 "Collection of soil and vegetation samples for the environmental surveillance program." These are surface soil samples appropriate for the deposition pathway and the exposure scenario (i.e., top 5 cm). Subsurface soil samples are not required as depositions would be to surfaces with little migration to deeper soil expected.
    b. Additional quality assurance for the collection of the samples is provided through LANL (2008) procedure QAPP-0001 "Quality and assurance project plan for the soils, foodstuffs, and non foodstuff biota monitoring project."
2) Soil sample analysis using appropriate EPA approved analytical procedures for each radionuclide. The following will be used by the independent laboratory:
    a. Environmental Measurements Laboratory (EML). **The procedures manual of the Environmental Measurements Laboratory**. Report HASL-300; 1997. Radionuclide specific procedures for the radionuclides of Am-241, Pu-239 and U-238 are provided in EML (EML 1997).
    b. Environmental Protection Agency (EPA). **Method 901.1 - Gamma Emitting Radionuclides in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from NTIS, document no. PB 80-224744.
    c. Environmental Protection Agency (EPA). **Method 905.0 - Radioactive Strontium in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from U.S. Department of Commerce, National Technical Information

Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, document no. PB 80-224744.

d. Environmental Protection Agency (EPA). **Method 906.0 - Tritium in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, document no. PB 80-224744.

After the measurements are completed, the laboratory results in units equivalent to the ALs will be evaluated with respect to the MQOs, as stated above.

2.10 Statistical Evaluation of the Survey Results

All the applicable data that has passed the MQO evaluation will be used to determine the upper-bound estimate of the mean for soil concentrations (generally, the 95% value) for each radionuclide. The EPA software ProUCL (EPA 2010) will be used to determine this value. The statistical decision as to whether the residual soil contamination levels (i.e., the 95% UCLs) are below the authorized limits will be evaluated using the following criteria. All analyses and results will be documented.

Decision Criteria:

5) When evaluating individual sample results, if all samples are ≤ the recreational AL, then no further action is required and the site passes the criteria for recreational occupation. No further actions are needed.

6) If all individual samples or the UCL are > the recreational AL, then the site is not a candidate for release and site remediation is needed, followed by resampling before it can be released.

7) If the UCL is below the AL but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background or very low relative to the AL, use the Sign Test. For Tract A-5-2, the Sign Test will be used with a $p < 0.05$ decision threshold for significance. See MARSSIM chapter 8 for details and examples.

8) Alternatively, one could confirm that the ratio of the upper-confidence level (UCL) of the average concentration divided by the AL and the sum of hot spot activity ratios do not exceed 1, as show in Equation 3.

$$\frac{\overline{C}_{UCL}}{C_{AL}} + \sum_{i=1}^{n} \frac{C_{i,C>AL}}{C_{AL} * AF} \leq 1 \qquad \text{(eqn. 2)}$$

Here $\overline{C}_{UCL}$ is the 95% upper bound estimate of the concentration mean, C_{AL} is the recreational AL (15 mrem yr^{-1}), $C_{i,c>AL}$ is the sample concentration for a single sample above the AL (i.e., has elevated measured concentrations), and AF is the Area Factor [ratio of effective dose calculated for area of contamination normalized to effective dose calculated for 10,000 m^2 (RESRAD default)]. If value in eqn. 2 is > 1, the site is a candidate for further characterization of the nature and extent of the contamination, remediation of the site, follow up confirmatory sampling, and reanalysis against the decision criteria in this section. Area Factors are dependent on the exposure scenario and should be calculated individually.

9) If there are multiple radionuclides (i) being evaluated in a sampling unit, the sum of the ratios should be less than or equal to 1, as shown in eqn. 1.

10) The dose assessment based on the soil measurements will include the sum of doses from all radionuclides, and this sum will be compared to the 3 mrem/yr threshold for follow up ALARA analysis.

3.0 Results of the Analysis for Sampling Number and Locations

The specific details of the analysis using MARSSIM and the results are provided in Attachment 1 of this report. Results showed that 11 randomly-sited samples were needed within Tract A-5-2. The approximate locations are drawn on Figure 3. Locations were randomly selected using a quasi-random number generator for x and y coordinates (Matzke et al. 2010). The specific statistical parameter values, analysis, results, and approximate coordinates for the randomly selected sampling locations are provided in the summary report (Attachment1).

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Table 1. Summary of preliminary data and comparisons to background and relevant SALs. Measurements are in units of pCi/g.

Radionuclide	Mean (1std)	Background	Recreational SAL	Construction Worker SAL
Am-241	0.077 (0.079)	0.013	280	34
Cs-137	0.351 (0.172)	1.65	210	18
Co-60	-0.003 (0.004)		46	4.1
Tritium	-0.907 (0.928)	0.08	5.3E6	3.2E5
Pu-238	0.009 (0.011)	0.023	330	40
Pu-239	0.500 (0.407)	0.054	300	36
Sr-90	0.194 (0.161)	1.31	5600	800
U-234	0.936 (0.242)	2.59	3200	220
U-235	0.033 (0.013)	0.2	520	43
U-238	0.988 (0.207)	2.29	2100	160

Figure 1. Map of the A-5-2 Tract.

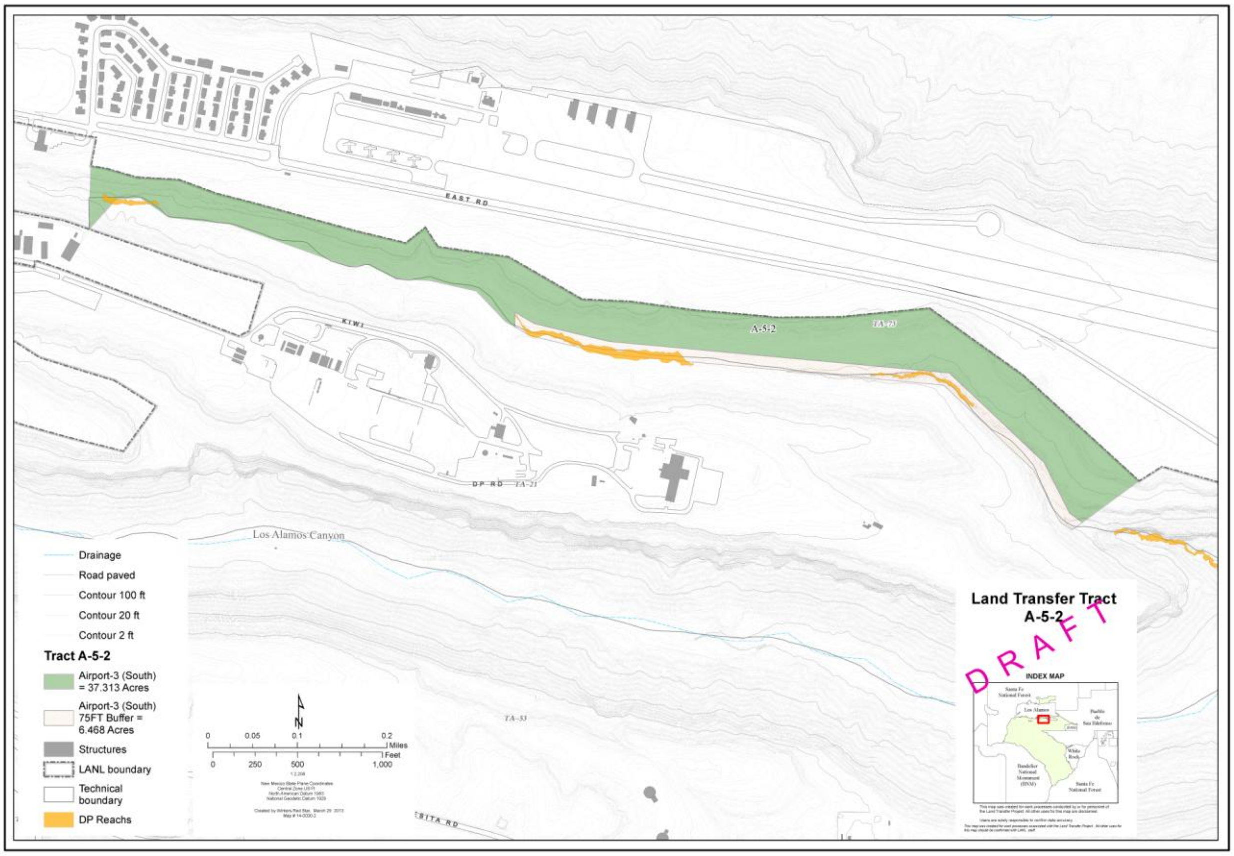


Figure 2. Map of previous sampling locations in DP Canyon. Data from sample locations 21-99, 21-100, 21-101, 21-102, 21-108, 21-109, 21-112, 21-113, and 21-114 (the north side of the canyon) were used in the preliminary assessment for development of the final SAP.

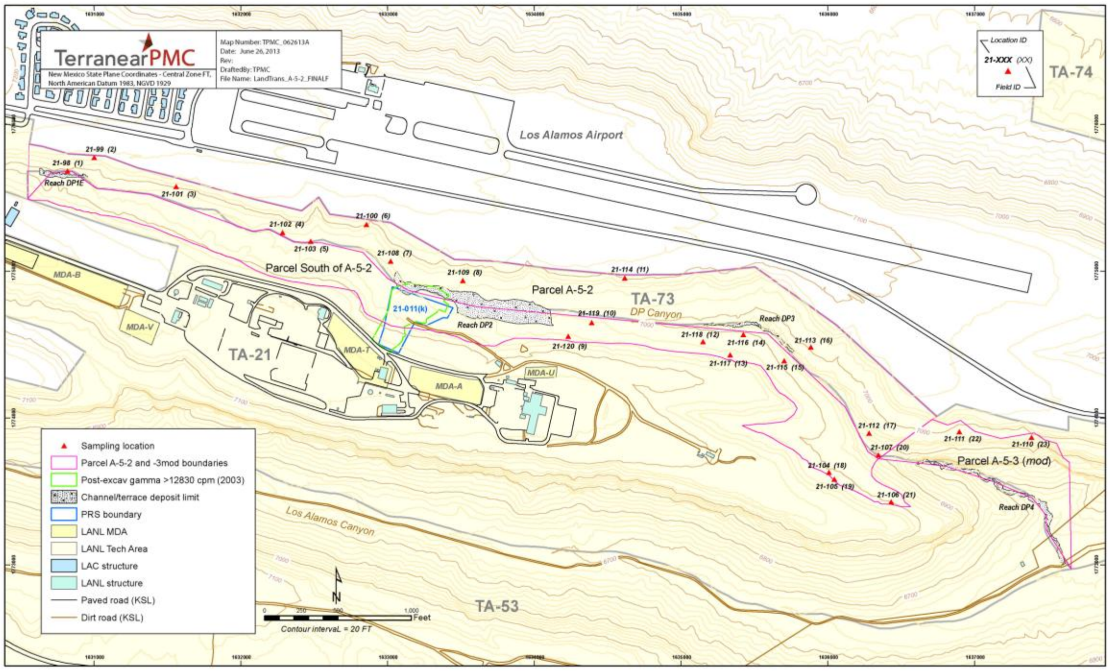


Figure 3. Map of sampling locations in A-5-2 Tract.

ATTACHMENT 1- Visual Sampling Plan Output

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

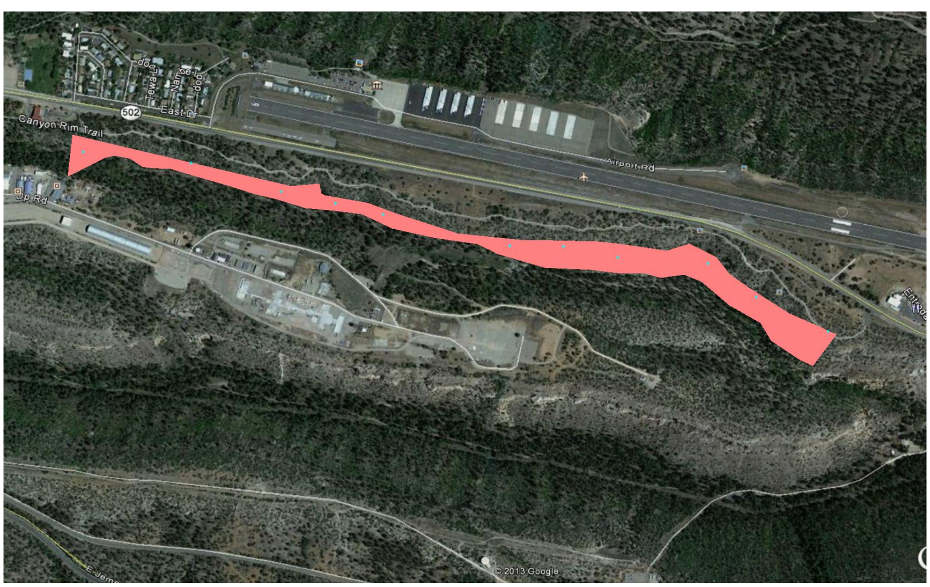
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	11
Number of samples on map [a]	11
Number of selected sample areas [b]	1
Specified sampling area [c]	109680.30 m^2

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.



Area: Area 5					
X Coord	Y Coord	Label	Value	Type	Historical
384467.3033	3971428.6450			Random	
384964.1757	3971295.9403			Random	
384839.9576	3971325.4302			Random	
384187.8126	3971458.1349			Random	
385429.9935	3971214.8430			Random	
385926.8659	3971082.1382			Random	
385802.6478	3971170.6081			Random	
386113.1930	3970994.0325			Random	
385290.2482	3971215.2070			Random	
384700.2122	3971355.2842			Random	
385569.7389	3971185.7171			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Cs-137	11	0.172 pCi/g	209 pCi/g	0.05	0.1	1.64485	1.28155
Am-241	11	0.079 pCi/g	889 pCi/g	0.05	0.1	1.64485	1.28155
Co-60	11	0.004 pCi/g	45 pCi/g	0.05	0.1	1.64485	1.28155
Pu-238	11	0.011 pCi/g	849 pCi/g	0.05	0.1	1.64485	1.28155
Pu-239	11	0.011 pCi/g	769 pCi/g	0.05	0.1	1.64485	1.28155
Sr-90	11	0.161 pCi/g	3199 pCi/g	0.05	0.1	1.64485	1.28155
U-234	11	0.242 pCi/g	2299 pCi/g	0.05	0.1	1.64485	1.28155
U-235	11	0.013 pCi/g	569 pCi/g	0.05	0.1	1.64485	1.28155
U-238	11	0.207 pCi/g	1699 pCi/g	0.05	0.1	1.64485	1.28155
H-3	11	0.928 pCi/g	129999 pCi/g	0.05	0.1	1.64485	1.28155

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ >

action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=3200		α=5		α=10		α=15	
		s=0.322	s=0.161	s=0.322	s=0.161	s=0.322	s=0.161
LBGR=90	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=80	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=70	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site median(mean) value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

Attachement 2

Dose Assessment of LANL-Derived Residual Radionuclides in Soils Within Tract A-5-3 for Land Transfer Decisions

August 2014

LA-UR-14-26915

1.0 Background for Tract A-5-3 Dose Assessment[1]

1.1 Site Location

The A-5-3 Tract is located just west of the eastern boundary of DP Mesa, Technical Area-21 (TA-21) and south of Highway 502 (Figure 1). The tract consists of the DP Canyon portion of the "Airport Tract" (DOE 1999). This tract contains undeveloped hillslope and lower canyon bottom accessed from DP Road or from Highway 502.

DP Canyon has an ephemeral stream and receives runoff from surrounding mesas and areas. The area is primarily covered in piñon-juniper woodlands, which have experienced an extensive die-off since the Cerro Grande fire in 2000 and the Las Conchas fire in 2011, partly as a result of drought and subsequent bark beetle infestations. The tract contains sensitive wildlife habitat. Specifically, habitat for the Mexican Spotted Owl overlaps this tract, and parts of the tract are foraging habitat for the bald eagle. Noise in the vicinity of this tract comes primarily from motor vehicles traveling along State Highway 502. There is a negligible amount of night-shine from the artificial light sources on the mesa top to the west.

1.2 Sampling and Analysis Plan

The Sampling and Analysis Plan (SAP) for Tract A-5-3 (Appendix A) was developed using a MARSSIM (MARSSIM 2000) approach, as required in DOE Order 458.1 and LANL procedures (LANL 2012b, c). The objective of the SAP was to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in soils in Tract A-5-3 are documented, in appropriate units, and are below the 15 mrem yr^{-1} Screening Action Levels (SALs), as derived in LANL (2012a). The SAP for Tract A-5-3 followed the LANL (2012b) procedure EDA-QP-238, "Dose Assessment Data Quality Objectives for Land Transfers into the Public Domain." The coordinates for the sampling locations are provided in Table 1.

1.2.1 Preliminary Results from Surveys for Residual Contamination

As detailed in the SAP for Tract A-5-3 (Attachment 1), previous measurements of soil concentrations were used as preliminary data to determine the potential for soil contamination in the tract and the standard deviation was used in the Sign Test to determine the number of samples required in the final survey of Tract A-5-3, as outlined in MARSSIM.

The preliminary analysis showed soil concentrations were below residential and recreational SALs, but elevated above background in some cases, though some of the samples were collected in the floodplain sediment where radionuclide concentrations could be expected to be higher relative to hillslopes (see Appendix A, Table 1). This preliminary data set suggested that the tract met the criteria for a Class 3 area under MARSSIM (potentially impacted by LANL operations, but the soil concentrations are expected to be near background levels and far lower than the SALs). Additionally, walk-over gamma surveys show Cs-137 from upstream contamination is largely confined to stream sediment (Gaul 2014). The Class 3 area designation does not require the decision areas be defined in less than 10,000 m^2 sections, and further, the southern portion of

[1] Portions of Sections 1.1, to 1.4.1 in the Background Section were directly imported into this document from the Environmental Baseline Survey (Pope et al. 2008) with slight formatting modifications.

this land conveyance is for recreational use, so the decision area of this portion is to match the exposure scenario of hikers and bikers, which can exceed the 10,000 m^2. Independent of the southern portion, the northern portion of the A-5-3 tract was tested against the residential screening criteria and although it was Class 3, the decision area was < 10,000 m^2. The sampling locations in both portions were randomly selected and are more representative of hillslope soil concentrations. Surface soils (0 -1 ft) were collected at each location. Details are provided in the SAP (Appendix A).

1.3 Statistical Analysis

The principle study question was: Does the residual radioactive contamination exceed Authorized Limits (ALs), individually or collectively, for the recreational exposure scenario (southern portion) or the residential exposure scenario (northern portion)?

The decision alternatives were:

- If results from the soil radioactive contamination measurements are at or above the AL (collectively), the sites are not candidates for land transfer.
- If results from the soil radioactive contamination measurements are below the AL (collectively), the sites are candidates for land transfer.

The decision rule was based on the null hypothesis that the mean residual contamination levels in soil and/or sediment in each portion of Tract A-5-3, individually or combined over all radionuclides, are above the ALs and likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment in Tract A-5-3 portions, individually or combined over all radionuclides, are below the AL and unlikely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}.

The assumed future land use and exposure pathway assumes recreational use for the southern portion and residential for the northern portions of tract A-5-3. The radionuclides analyzed for and the respective recreational ALs are provided in Tables 3a and 3b. The 15 mrem yr^{-1} ALs used in this analysis were calculated using RESRAD (RESRAD 2001), as documented in LANL (2012a).

1.3.1 Statistical Evaluation of the Survey Results

All the applicable data that has passed the Measurement Quality Objective (MQO) evaluation was used to determine the upper-bound confidence level (UCL) estimate of the mean for soil concentrations (generally, the 95 percent value) for each radionuclide. The EPA software ProUCL (EPA 2010) was used to determine the UCLs. The analyses were done at an independent laboratory and all passed requisite DQOs, as required for the comparisons to the ALs.

The statistical decisions as to whether the residual soil contamination levels (i.e., the 95 percent UCLs) were below the authorized limits were evaluated using the following criteria.

Decision Criteria:

1) If all samples are ≤ the respective residential or recreational ALs, then no further action is required and the sites pass the criteria for release to the public. No further actions are needed.
2) If all samples or the UCL are > the AL, then the site is not a candidate for release and site remediation is needed followed by resampling before it can be released.
3) If the UCL is below the AL but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background or very low relative to the AL, use the Sign Test. For tract A-5-3, the Sign Test will be used with a $p < 0.05$ decision threshold for significance. See MARSSIM chapter 8 for details and examples.
4) Because of multiple radionuclides, we also tested that the ratio of the upper-confidence level (UCL) of the average concentration divided by the AL and the sum of the ratios did not exceed 1, as show in eqn. 1. Because there was no indication or reasonable physical mechanism to create hot spots, we assumed that the contamination was homogeneously distributed across the tract.

$$\sum_{i-1}^{n} \frac{\overline{C}_{UCL,i}}{C_{AL}} \leq 1 \qquad \text{(eqn.1)}$$

Here $\overline{C}_{UCL}$ is the 95 percent upper bound estimate of the concentration mean, C_{AL} is either the residential or the recreational AL (15 mrem yr^{-1}).

1.3.2 ALARA Evaluation

LANL policy P410 “Los Alamos National Laboratory Environmental ALARA Program” (LANL 2011) requires an ALARA evaluation based on procedure SOP-5254 “Performing ALARA Analysis for Public Exposures” (LANL 2009b). If the calculated individual dose exceeds 3 mrem yr^{-1}, then a quantitative ALARA evaluation is performed.

1.4 Instrumentation and Measurement Quality Objectives

The main objectives are to determine an appropriate analysis technique for each radionuclide and ensure Measurement Quality Objectives (MQOs) are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

1.4.1 Measurement Quality Objectives:

- Detection Capability: Minimum Detection Concentration (MDC) should be below the MARSSIM defined Lower Bound of the Gray Region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported and the level reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.

- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.

- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements. However, in this case, all samples will be analyzed in the laboratory.

2.0 Results and Analyses of Measurements

Table 2 provides the measurements of soil concentrations for the randomly selected locations and categorized into the northern and southern sections. Averages, standard deviations, 95 percent UCLs, and ALs for each of the radionuclides are provided in Table 3. Results show that all radionuclides were at (within 2 standard deviations) or below regional background soil concentrations and that all concentrations were below the ALs and meet the real property release criteria. Combining all radionuclides by using Eqn. 1, the sum of the ratios of the 95 percent UCL without background subtraction divided by the ALs was 2.9 mrem yr^{-1} for the northern portion of A-5-3 (residential use) and 0.1 for the southern portion (recreational use).

2.1 ALARA Analysis

Tables 3 shows that the estimated dose not corrected for background was 2.95 mrem yr^{-1} for samples from the northern portion. Because this effective dose rate is close to the LANL 3 mrem/yr ALARA goal, background dose was subtracted to solely assess the LANL contribution to this dose. The same data with background subtracted resulted in a dose of 1.34 mrem per yr^{-1}. The dose for the southern portion was 0.11 mrem yr^{-1}. Because none of these doses exceed the threshold of 3 mrem yr^{-1} for performing a quantitative ALARA analysis, no further ALARA analysis is required in accordance with PD410, Los Alamos National Laboratory Environmental ALARA Program, and the calculated doses are therefore considered ALARA.

2.2 Quality Assurance

Soils were collected according to procedures and the laboratory analysis techniques were appropriate for the specific radionuclides, as required in the SAP for A-5-3 (Appendix A). The analysis at the independent laboratory was within their predefined boundaries and met all quality assurance requirements. Only qualified data was used in this analysis and minimum detectable concentrations were below the LBGR. Thus, all measurement quality objectives were met for this data set.

2.3 Conclusion

Given that in each the northern and southern portions of the tract A-5-3 1) all the measurements were below the ALs for each individual radionuclide, 2) the sum of the ratios was below 1, and 3) the resulting combined calculated dose was less than the 15 mrem yr^{-1} for a hypothetical residential and recreational user, we conclude that all of Tract A-5-3 south is a candidate for conveyance to the public for recreational use and A-5-3 north is a candidate for conveyance to the public for residential use. Additionally, the soil concentrations of any residual radioactive contamination in both portions of A-5-3 are significantly lower than ALs for construction workers and we found no evidence of pockets of contamination. Thus, it is likely that potential doses resulting from other short-term (e.g., <1mo) construction-like or maintenance activities within the tract such as trenching, fence installation, digging, etc. would likely meet the dose criteria objectives without dose assessment. Specific sampling and dose assessments for more involved work can be done if there are concerns of dose for specific jobs performed within the tract.

3.0 REFERENCES

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Table 1. Coordinates for randomly selected sample locations

Sample ID[a]	Location ID	Sample Usage	Depth (ft bgs) [b]	Media	Northing (ft)[c]	Easting (ft)[c]	Comments
CADP-14-81437	DP-60117	INV	0–0.5	Soil	1774097.041	1636916.064	—[d]
CADP-14-81438	DP-60118	INV	0–1	Soil	1773191.662	1637498.620	Split sample taken with DOE/Tidewater at this location
CADP-14-81439	DP-60119	INV	0–1	Soil	1773804.404	1636554.491	Proposed sampling location moved approximately 138 ft southwest to avoid cliff
CADP-14-81440	DP-60120	INV	0–1	Soil	1773599.069	1637417.180	—
CADP-14-81441	DP-60121	INV	0–0.5	Soil	1773665.670	1637301.981	—
CADP-14-81442	DP-60122	INV	0–0.5	Soil	1773668.738	1637185.193	Proposed sampling location moved approximately 85 ft south to avoid cliff
CADP-14-81443	DP-60123	INV	0–1	Soil	1773733.626	1637502.031	Proposed sampling location moved approximately 36 ft west to avoid cliff
CADP-14-81444	DP-60124	INV	0–0.5	Soil	1774057.347	1636877.702	—
CADP-14-81445	DP-60125	INV	0–0.5	Soil	1773872.872	1636767.808	Proposed sampling location moved approximately 49 ft north to avoid cliff
CADP-14-81446	DP-60126	INV	0–0.5	Soil	1773968.058	1636993.190	—
CADP-14-81447	DP-60127	INV	0–0.5	Soil	1773873.977	1637118.281	Proposed sampling location moved approximately 72 ft north to avoid cliff
CADP-14-81448	DP-60128	INV	0–0.5	Soil	1773913.984	1637222.282	Proposed sampling location moved approximately 23 ft south to avoid cliff
CADP-14-81449	DP-60129	INV	0–1	Soil	1773871.810	1637451.808	—
CADP-14-81450	DP-60130	INV	0–0.5	Soil	1773970.783	1637566.878	Split sample taken with DOE/Tidewater at this location
CADP-14-81451	DP-60131	INV	0–0.5	Soil	1773949.890	1637492.238	—

Sample ID[a]	Location ID	Sample Usage	Depth (ft bgs) [b]	Media	Northing (ft)[c]	Easting (ft)[c]	Comments
CADP-14-81452	DP-60132	INV	0–0.5	Soil	1774021.474	1637342.690	Proposed sampling location moved approximately 39 ft north to avoid cliff
CADP-14-81453	DP-60133	INV	0–0.25	Soil	1774057.935	1637366.010	—
CADP-14-81454	DP-60134	INV	0–0.5	Soil	1774037.042	1637291.370	—
CADP-14-81455	DP-60135	INV	0–0.5	Soil	1774057.252	1637196.604	Proposed sampling location moved approximately 66 ft north to avoid cliff
CADP-14-81456	DP-60136	INV	0–0.25	Soil	1774106.392	1637144.373	Proposed sampling location moved approximately 10 ft south to avoid exposed bedrock
CADP-14-81457	DP-60137	INV	0–1	Soil	1774156.012	1637239.910	—
CADP-14-81458	DP-60138	INV	0–0.5	Soil	1774169.047	1637089.927	—
CADP-14-81459	DP-60139	INV	0–0.5	Soil	1774189.940	1637164.568	—
CADP-14-81460	DP-60140	INV	0–0.5	Soil	1774078.064	1636991.214	—
CADP-14-81434	DP-60125	FD	0–0.5	Soil	1773872.872	1636767.808	Field duplicate of sample CADP-14-81445
CADP-14-81435	DP-60132	FD	0–0.5	Soil	1774021.474	1637342.690	Field duplicate of sample CADP-14-81452
CADP-14-81436	DP-60138	FD	0–0.5	Soil	1774169.047	1637089.927	Field duplicate of sample CADP-14-81458

Table 2. Soil concentrations for all samples and categorized by radionuclide. The locations are split between the north portion of A-5-3 and the southern portions. Results are in pCi/g.

Location ID	Am-241	Cs-137	Co-60	Pu-238	Pu-239	Sr-90	Tritium	U-234	U-235	U-238
A-5-3 North-Residential										
DP-60117	0.24	0.673	0.014	0.049	0.085	0.23	-2.027	1.111	0.039	1.352
DP-60130	0.043	0.678	-0.01	0	0.132	-0.016	-1.099	0.975	0.036	0.976
DP-60131	0.148	1.391	0.001	0.02	0.23	0.185	-0.911	1.079	0.041	1.258
DP-60132	0.087	0.479	0.011	0.039	0.297	0.267	-1.099	1.029	0.02	0.991
DP-60133	0.337	0.41	-0.001	0.021	0.124	0.015	-1.259	0.964	0.027	1.063
DP-60134	0.059	0.394	-0.019	0.023	0.126	0.182	0.653	0.749	0.017	0.812
DP-60135	0.141	1.76	-0.001	0.015	0.264	0.14	1.355	1.093	0.077	1.205
DP-60136	0.138	0.501	-0.007	0.03	0.094	0.15	-1.082	0.969	0.024	0.854
DP-60137	0.164	0.28	-0.008	0.031	1.25	0.031	-1.06	0.783	0.023	0.903
DP-60138	0.055	0.894	0.008	0.033	0.235	0.257	-0.385	1.139	0.041	1.233
DP-60139	0.168	0.051	-0.031	0.008	0.264	0.194	-0.029	0.878	0.027	0.805
DP-60140	0.099	0.518	-0.001	0.015	0.186	0.281	-0.147	0.95	0.047	0.974
A-5-3 South-Recreational										
DP-60118	0.731	1.993	-0.002	0.084	0.456	0.714	-1.918	0.983	0.067	0.859
DP-60119	0.182	0.366	-0.003	0.022	0.127	0.165	-1.344	0.76	0.023	0.793
DP-60120	0.367	0.36	0.003	0.063	0.083	0.078	0.224	1.044	0.048	1.169
DP-60121	0.044	0.179	-0.014	0.006	0.034	0.042	0.045	0.87	0.036	0.893
DP-60122	0.033	0.291	0.012	0.024	0.168	-0.12	0.11	2.253	0.096	2.273
DP-60123	0.029	0.211	0.02	0.013	0.022	0.101	0.378	0.547	0.031	0.583
DP-60124	0.077	1.815	0.026	0.017	0.34	0.338	0.9	1.272	0.053	1.474
DP-60125	0.072	0.443	0.021	0.023	0.094	0.047	0.368	0.649	0.033	0.646
DP-60126	0.186	0.81	0	0.036	0.125	0.142	0.402	0.856	0.038	0.972
DP-60127	0.045	0.518	-0.008	0.016	0.051	0.19	0.831	0.925	0.037	0.906
DP-60128	0.036	0.798	0	0.046	0.132	0.286	0.361	0.726	0.029	0.819
DP-60129	0.015	0.312	0.001	0.017	0.102	0.022	1.888	0.859	0.021	0.863

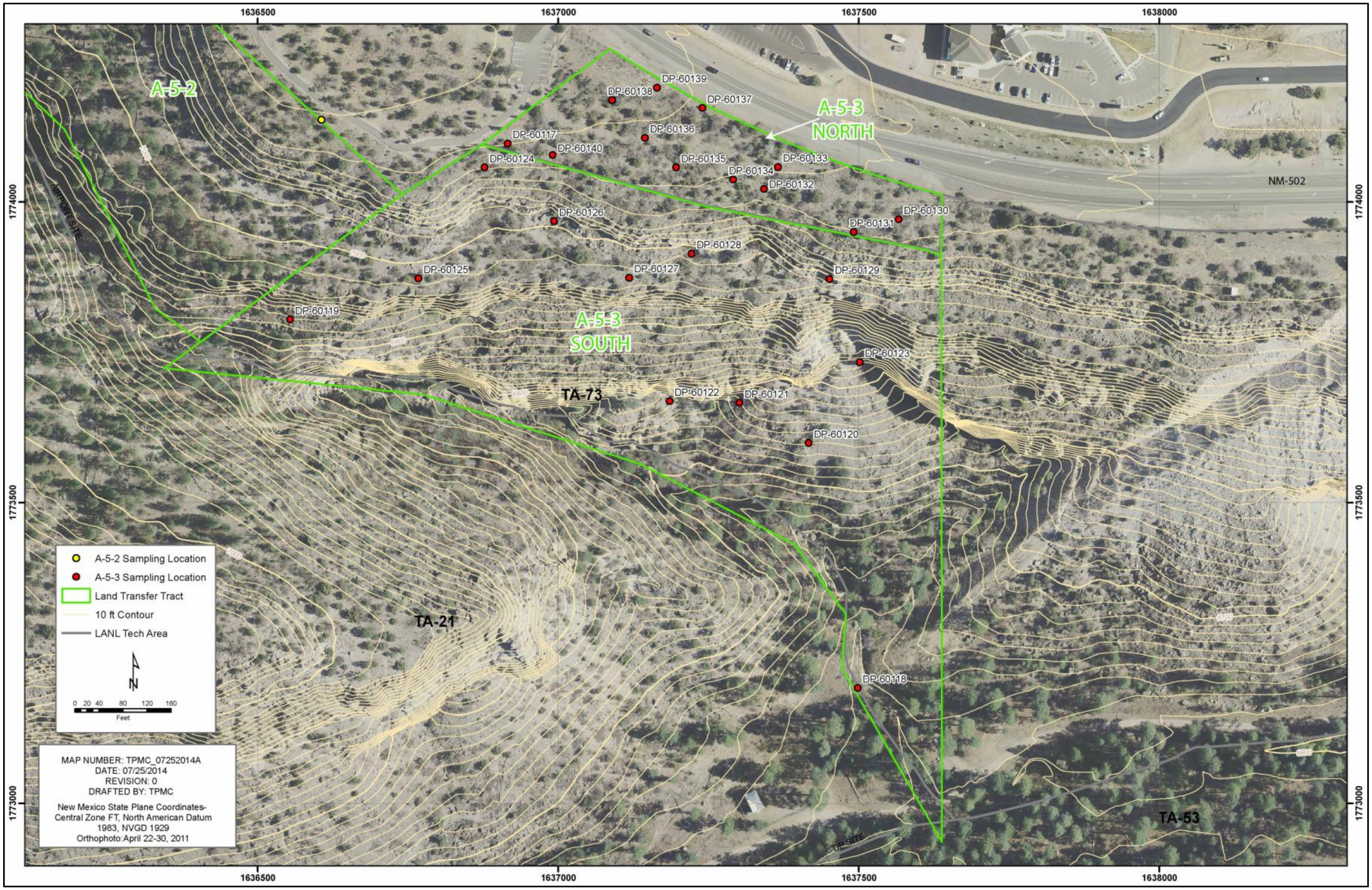
Table 3a and 3b. Soil concentration results in pCi/g for northern and southern portions of A-5-3. Background and SAL concentration levels are provided for context. Background dose is subtracted from north portion due to proximity to the 3 mrem/yr ALARA goal.

Table 3a: Tract A-5-3 North Portion- Evaluated Under Residential Land Use Criteria										
	Am-241	**Cs-137**	**Co-60**	**Pu-238**	**Pu-239**	**Sr-90**	**H-3**	**U-234**	**U-235**	**U-238**
Mean	0.140	0.669	-0.004	0.024	0.274	0.160	-0.591	0.977	0.035	1.036
STD	0.084	0.479	0.013	0.014	0.316	0.101	0.928	0.125	0.016	0.186
Max	0.337	1.760	0.014	0.049	1.250	0.281	1.355	1.139	0.077	1.352
Min	0.043	0.051	-0.031	0.000	0.085	-0.016	-2.027	0.749	0.017	0.805
95% UCL	0.184	0.917	0.003	0.031	0.439	0.212	-0.110	1.041	0.044	1.132
Background	0.006	0.420	-----	0.005	0.015	0.360	0.130	1.400	0.087	1.220
Residential SAL	49	6.7	1.5	50	48	9	510	160	23	92
Dose (mrem/yr)	5.63E-02	2.05E+00	3.00E-02	9.30E-03	1.37E-01	3.53E-01	-3.24E-3*	9.76E-02	2.87E-02	1.85E-01
Summed dose	2.95E+00									
Bkg subtracted dose	5.45E-02	1.11E+00	3.00E-02	7.80E-03	1.33E-01	-2.47E-1*	-7.06E-3*	-3.37E-2*	-2.80E-2*	-1.43E-2*
Summed dose w/o bkg	1.34E+00									

*Negative UCLs set to zero for dose calculations

Table 3b: Tract A-5-3 South Portion- Evaluated Under Residential Land Use Criteria										
	Am-241	**Cs-137**	**Co-60**	**Pu-238**	**Pu-239**	**Sr-90**	**H-3**	**U-234**	**U-235**	**U-238**
Mean	0.151	0.675	0.005	0.031	0.145	0.167	0.187	0.979	0.043	1.021
STD	0.209	0.609	0.012	0.023	0.128	0.211	0.989	0.444	0.021	0.458
Max	0.731	1.993	0.026	0.084	0.456	0.714	1.888	2.253	0.096	2.273
Min	0.015	0.179	-0.014	0.006	0.022	-0.120	-1.918	0.547	0.021	0.583
95% UCL	0.295	1.059	0.011	0.046	0.231	0.276	0.700	1.209	0.550	1.258
Background	0.006	0.420		0.005	0.015	0.360	0.130	1.400	0.087	1.220
Recreational SAL	890	210	46	850	770	3200	4.30E+05	2300	570	1700
Dose (mrem/yr)	4.97E-03	7.56E-02	3.59E-03	8.06E-04	4.50E-03	1.29E-03	2.44E-05	7.88E-03	1.45E-02	1.11E-02
Summed dose	1.11E-01									

Figure 1. Location of Tract A-5-3 along State Road 502 and in relation to Tract A-5-2.



APPENDIX A

Sampling and Analysis Plan for A-5-3

1.0 Background for A-5-3

1.1 Site Location

The A-5-3 Tract is located just west of the eastern boundary of DP Mesa, Technical Area-21 (TA-21) and south of Highway 502 (Figure 1). The tract consists of the DP Canyon portion of the “Airport Tract” (DOE 1999). This tract contains undeveloped hillslope and canyon bottom accessed from DP Road. Vegetation includes ponderosa and piñon-juniper woodlands with open shrub, grasslands, and wildflower areas; A-5-3 is considered potentially sensitive wildlife habitat. DP Canyon has an ephemeral stream and receives runoff from surrounding mesas and areas.

This approximately 16-acre tract is located south of Los Alamos County (LAC) Airport (transferred from DOE to LAC in October 2008) and other variously owned County land and private properties. Figure 1 shows the boundaries for Tract A-5-3.

1.2 General History

Historical maps from the pre-LANL era (1924), aerial photographs (1935), and historical accounts of life in the area show little development prior to LANL occupancy (pre World War II). Detroit businessman Ashley Pond started the “Los Alamos Ranch School” in 1917. The school began with a few ranch buildings from the Harold H. Brook homestead.

Laboratory operations began on nearby DP Mesa, just west of Tract A-5-3, in the late 1940s. Plutonium processing operations were conducted on DP Mesa in Tract A-16 or in the technical area TA-21. Additionally, waste disposal operations were conducted at what is now designated Material Disposal Area B (MDA B) on the mesa-top in the western portion of Tract A-16. Tract A-10 has remained vacant throughout except for a well-drilling site.

There are no Potential Release Sites (PRSs) located on the A-5-3 tract, but there are several PRSs that are associated with the historical Laboratory operations on adjacent lands.

1.3 Current Use

Tract A-5-3 is unoccupied, vacant land, with the exception of a groundwater monitoring well. No structures or facilities associated with LANL’s federal, state, or local permits (such as air monitoring stations, radiation monitoring stations, or wastewater discharge outfalls) are located within A-5-3. This tract was never actively used by the Laboratory, no Laboratory operations were conducted within the tract boundaries, and no Laboratory structures were situated within the tract.

1.4 Summary of Historical Evaluation of LANL Impact

There are records of radioactive materials being spilled into the canyon bottom (Cs-137 and Sr-90 and Am-241) and air fall from historical operations at TA-21, southeast of this tract, and stack emissions from TA-1 may have resulted in surface deposition of radionuclides, particularly plutonium (LANL 2004).

Tract A-5-3 does not meet the CERCLA 120(h) “uncontaminated” definition, even though DOE/NNSA and LANL believe all remedial actions necessary to address the known contamination on this tract, and allow its unrestricted transfer, have been completed according to the requirements of PL 105-119. Because Tract A-10 is not “uncontaminated,” CERCLA Section 120(h)(4) is not applicable.

1.4.1 Adjacent Properties with Known or Suspected Releases

SWMU 21-029 and Consolidated Unit 21-021-99 are located immediately west of the A-5-3 tract. The remainder of the DP Canyon PRS, AOC C-00-021 is located directly west (upgradient) of the A-5-3 tract. See LANL 2004 for the history of use, site investigation and remediation activities. The southern boundary of Tract A-5-3 is approximately 75 feet upslope from the canyon bottom, and the tract does not include the sediment in the floodplain that is known to contain residual radionuclides.

1.5 Preliminary Results from Surveys for Residual Contamination

Figure 2 shows soil sampling locations for DP canyon taken in 2013. From these, a subset of samples nearest the A-5-3 tract was selected to be representative of the tract. Table 1 provides the soil concentration data from these samples, summary statistics, regional background levels, and reference threshold concentrations derived for residential and recreational use. Included in this data set is a sample taken from the contaminated sediment (#21-107), which elevates the mean and the standard deviation for the measurements. Using the sediement and soil, the results show that the concentrations are above background levels for Am-241, Cs-137, Pu-238 and Pu-239. However, all preliminary measurements are significantly below all SALs for each of these radionuclides.

1.6 Conclusions regarding the classification of Tract A-5-3 relative to potential for residual radioactive contamination

There are properties adjacent or near to Tract A-5-3 that are either contaminated or have emitted radionuclides historically, and some LANL impact to the tract is possible (LANL 2004). The level of this impact is likely small as suggested by the data from the two preliminary soil samples taken within the tract (21-110 and 21-111), which were near background levels (Table 1). Additionally, walk-over gamma surveys show Cs-137 from upstream contamination is largely confined to stream sediment and does not spread upslope into Tract A-5-3 (Gaul 2014). Thus, low-levels of residual contamination potentially exist on A-5-3 from activities conducted by LANL in nearby areas starting from the late 1940s; however, soil concentrations of radionuclides in soil from measurements shown in Table 1 and other past measurements in DP Canyon suggest that general levels are likely to be below all SALs, regardless of land use. Thus, DOE/NNSA believes no additional remedial activities are needed on the A-5-3 tract. Based on this assessment, the A-5-3 tract qualifies as a Class 3 area under MARSSIM (i.e., potentially impacted with concentrations of residual radioactive material in soils elevated, but likely to be significantly below thresholds and near background levels (MARSSIM 2000).

2.0 Data Quality Objectives for Sampling and Analysis Plan

The sampling and analysis plan (SAP) for Tract A-5-3 follows the LANL (2012b) procedure EDA-QP-238, "Dose assessment data quality objectives for land transfers into the public domain."

2.1 Objective of the Sampling and Analysis Plan

The objective of this sampling and analysis plan is to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in soils in the tract A-5-3 are documented, in appropriate units, and are below the 15 mrem yr^{-1} Screening Action Levels (SALs), as derived in LANL (2012) for the radionuclides of concern are provided in Table 1. **These and other SALs are used by LANL as preapproved Authorization Limits (ALs), as required in DOE Order 458.1 (section 2.k.(6)(f)2 in the contractors Requirements Document), and are identified as ALs in the rest of this SAP with regards to statistical decisions.** The entire tract was divided into two sub regions for sampling. The northern region, along the mesa top and near East Road, will be evaluated for residential use and the southern region of Tract A-5-3 will be evaluated for recreational use.

2.2 Decision identification

The principle study question is: Does the residual radioactive contamination exceed ALs for the either the residential exposure scenario (northern portion) or the recreational exposure scenario (southern portion)? The decision alternatives are:

- If results from the soil radioactive contamination measurements are at or above the AL (collectively) for soil, the site is not a candidate for land transfer.
- If results from the soil radioactive contamination measurements are below the AL (collectively) for soil, the site is a candidate for land transfer.

2.3 Inputs into the Decision

The assumed near-term future land use and exposure pathway assumes recreational use for A-5-3 South, and residential for A-5-3 North. ALs used for all the radionuclides analyzed for and the respective residential SAL is provided in Table 1, and the derivation of the SALs is provided in LANL (2012). The 15 mrem yr^{-1} SALs used in this analysis were calculated using RESRAD (RESRAD 2001).

Data to be used in the analysis include preliminary surface soil concentration measurements in (Table 1), which were used in the development of the Sampling and Analysis Plan. The unity rule will be applied because there are multiple radionuclides in the analysis. The formula used in for the unity rule is:

$$\frac{\boldsymbol{C_1}}{\boldsymbol{AL_1}} + \frac{\boldsymbol{C_2}}{\boldsymbol{AL_2}} + \frac{\boldsymbol{C_3}}{\boldsymbol{AL_3}} \dots\dots . \frac{\boldsymbol{C_n}}{\boldsymbol{AL_n}} \leq \mathbf{1} \qquad \text{(eqn. 1)}$$

where $C_{1\text{-}n}$ and $AL_{1\text{-}n}$ are the upper-bound estimates of the mean concentrations for radionuclides (e.g., upper 95% values) and Authorized Levels 1 through n, respectively.

2.4 Study Boundaries

The study is limited to Tract A-5-3, as identified in Figure 1. As concluded from historical information and previous sediment sampling, the list of radionculides in the analysis include Am-241, Cs-137, H-3, Pu-239, Pu-238, Sr-90, U-234, U235, and U-238. Individual doses are evaluated out to 1000 years.

2.5 Decision Rule

The decision rule is based on the null hypothesis that the mean residual contamination levels in soil and/or sediment in the northern and southern portions of the Tract A-5-3 combined over all radionuclides is above the AL and likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment in Tract A-5-3 combined over all radionuclides is below the AL and not likely to result in an all pathway radiation dose to the critical receptor above 15 mrem yr^{-1}. The northern and southern portions of A-5-3 will be analyzed individually because of differing land use and SALs thresholds.

2.6 Limits on Decision Errors

The acceptable statistical errors for this analysis are that Type I error (i.e., conclude contamination levels at site are < AL when in fact it is > AL) has a probability of $p < 0.05$; and the Type II error is (i.e., conclude soil contamination level is > AL when in fact it is < AL) has a probability of $p < 0.1$. Normality of the distribution for the preliminary data is not assumed.

2.7 Optimization of Design Process

The survey design is optimized by analyzing historical data. Specifically, there is no evidence of radiological operations in Tract A-5-3 with minimal impact from surrounding LANL operations, and the preliminary sediment data support this conclusion. Thus, the entire tract will be treated as a Class 3 area optimizing the number of required sample locations.

2.8 Statistically-Based Evaluation for Number of Samples Required using MARSSIM

Google Earth was used to download a map of the Tract A-5-3 area, which was then incorporated into Visual Sampling Plan (VSP) software (Matzke et al. 2010). The approximate boundary of the A-5-3 tract within was then delineated as a sampling area (Figures 1 and 3). The MARSSIM application within VSP was then used to determine the statistically-based sampling plan. The preliminary sampling data in Table 1 was used to determine the standard deviations needed for calculating the needed number of samples for each of the identified radionuclides. The sampling locations were randomly determined.

2.9 Instrumentation and Measurement Quality Objectives

The main objectives are to determine appropriate analysis technique for each radionuclide and ensure Measurement Quality Objectives are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

2.9.1 Measurement Quality Objectives:

- Detection Capability: Minimum Detection Concentration (MDC) should be below the MARSSIM defined Lower Bound of the Gray Region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported and the level reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.
- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.
- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements. However, in this case, all samples will be analyzed in the laboratory.

2.9.2 Procedures used to meet these measurement quality objectives:

1) Collection of valid soil sample appropriate for the dose assessment,
    a. Sampling of soil will be done using LANL (2012a) procedure SOP-5132 "Collection of soil and vegetation samples for the environmental surveillance program." These are surface soil samples appropriate for the deposition pathway and the exposure scenario (i.e., top 5 cm). Subsurface soil samples are not required as depositions would be to surfaces with little migration to deeper soil expected.
    b. Additional quality assurance for the collection of the samples is provided through LANL (2008) procedure QAPP-0001 "Quality and assurance project plan for the soils, foodstuffs, and non foodstuff biota monitoring project."
2) Soil sample analysis using appropriate EPA approved analytical procedures for each radionuclide. The following will be used by the independent laboratory:
    a. Environmental Measurements Laboratory (EML). **The procedures manual of the Environmental Measurements Laboratory**. Report HASL-300; 1997. Radionuclide specific procedures for the radionuclides of Am-241, Pu-239 and U-238 are provided in EML (EML 1997).
    b. Environmental Protection Agency (EPA). **Method 901.1 - Gamma Emitting Radionuclides in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from NTIS, document no. PB 80-224744.
    c. Environmental Protection Agency (EPA). **Method 905.0 - Radioactive Strontium in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's

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d. Environmental Protection Agency (EPA). **Method 906.0 - Tritium in Drinking Water***: Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA 600/4-80-032, prepared by EPA's Environmental Monitoring and Support Laboratory, August 1980 (EPA 1980). Available from U.S. Department of Commerce, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, document no. PB 80-224744.

After the measurements are completed, the laboratory results in units equivalent to the ALs will be evaluated with respect to the MQOs, as stated above.

2.10 Statistical Evaluation of the Survey Results

All the applicable data that has passed the MQO evaluation will be used to determine the upper-bound estimate of the mean for soil concentrations (generally, the 95% value) for each radionuclide. The EPA software ProUCL (EPA 2010) will be used to determine this value. The statistical decision as to whether the residual soil contamination levels (i.e., the 95% UCLs) are below the authorized limits will be evaluated using the following criteria. All analyses and results will be documented.

Decision Criteria:

5) If all samples are ≤ residential (north portion) or recreational (south portion) AL, then no further action is required and the sites pass the criteria for residential/recreational occupation. No further actions are needed.

6) If all samples or the UCL are > the appropriate ALs, then the site is not a candidate for release and site remediation is needed followed by resampling before it can be released.

7) If the UCLs are below the ALs but some individual measurements are above the ALs, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum test is suggested, and if contamination is not present in background or very low relative to the AL, use the Sign Test. For Tract A-5-3, the Sign Test will be used with a $p < 0.05$ decision threshold for significance. See MARSSIM chapter 8 for details and examples.

8) Alternatively, one could confirm that the ratio of the upper-confidence level (UCL) of the average concentration divided by the AL and the sum of hot spot activity ratios do not exceed 1, as show in Equation 2.

$$\frac{\overline{C}_{UCL}}{C_{AL}} + \sum_{i=1}^{n} \frac{C_{i,C>AL}}{C_{AL} * AF} \leq 1 \qquad \text{(eqn. 2)}$$

Here $\overline{C}_{UCL}$ is the 95% upper bound estimate of the concentration mean, C_{AL} is the resident AL (15 mrem yr^{-1}), $C_{i,c>AL}$ is the sample concentration for a single sample above the AL (i.e., has elevated measured concentrations), and *AF* is the Area Factor [ratio of effective dose calculated for area of contamination normalized to effective dose calculated for 10,000 m^2 (RESRAD default)]. If value in eqn. 2 is > 1, the site is a candidate for further characterization of the nature and extent of the contamination, remediation of the site, follow up confirmatory sampling, and reanalysis against the decision criteria in this section. Area Factors are dependent on the exposure scenario and should be calculated individually.

9) If there are multiple radionuclides (*i*) being evaluated in a sampling unit, the sum of the ratios should be less than one, as shown in eqn. 1.

3.0 Results of the Analysis for Sampling Number and Locations

The specific details of the analysis using MARSSIM and the results are provided in Attachment 1 of this report. Results showed that approximately 24 randomly-sited samples were needed within the Tract A-5-3 and the approximate locations are drawn on Figure 2. Locations were randomly selected using a quasi-random number generator for x and y coordinates (Matzke et al. 2010). The specific statistical parameter values, analysis, results, and approximate coordinates for the randomly selected sampling locations are provided in the summary report (Attachment1).

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4.1 HISTORICAL RECORDS AND OTHER PERTINENT DOCUMENTS

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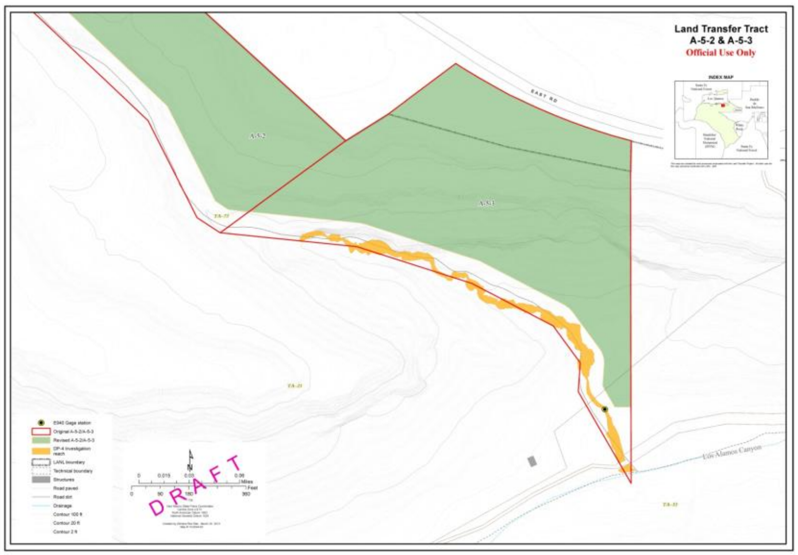
Figure 1. Map of Tract A-5-3 in relation to Tract A-5-2 and East Road is shown in 1(a). The A-5-3 Tract in Figure 1(a) is highlighted in green and does not include the DP Canyon floodplain. Figure 1(b) is an orthoimage map showing the tract in relation to State Road 502 and businesses across the highway.

(a)



(b)

Figure 2. Location of soil samples taken in DP Canyon. Sample results from 21-104, 105, 106, 107, 110, 111, and 21-112 were used for the preliminary assessment for residual contamination for Tract A-5-3. See Table 1 for these results. (It should be noted the boudaries in this map are no longer valid and have since been redrawn, but the sample locations shown are valid for prelininary analysis purposes.)

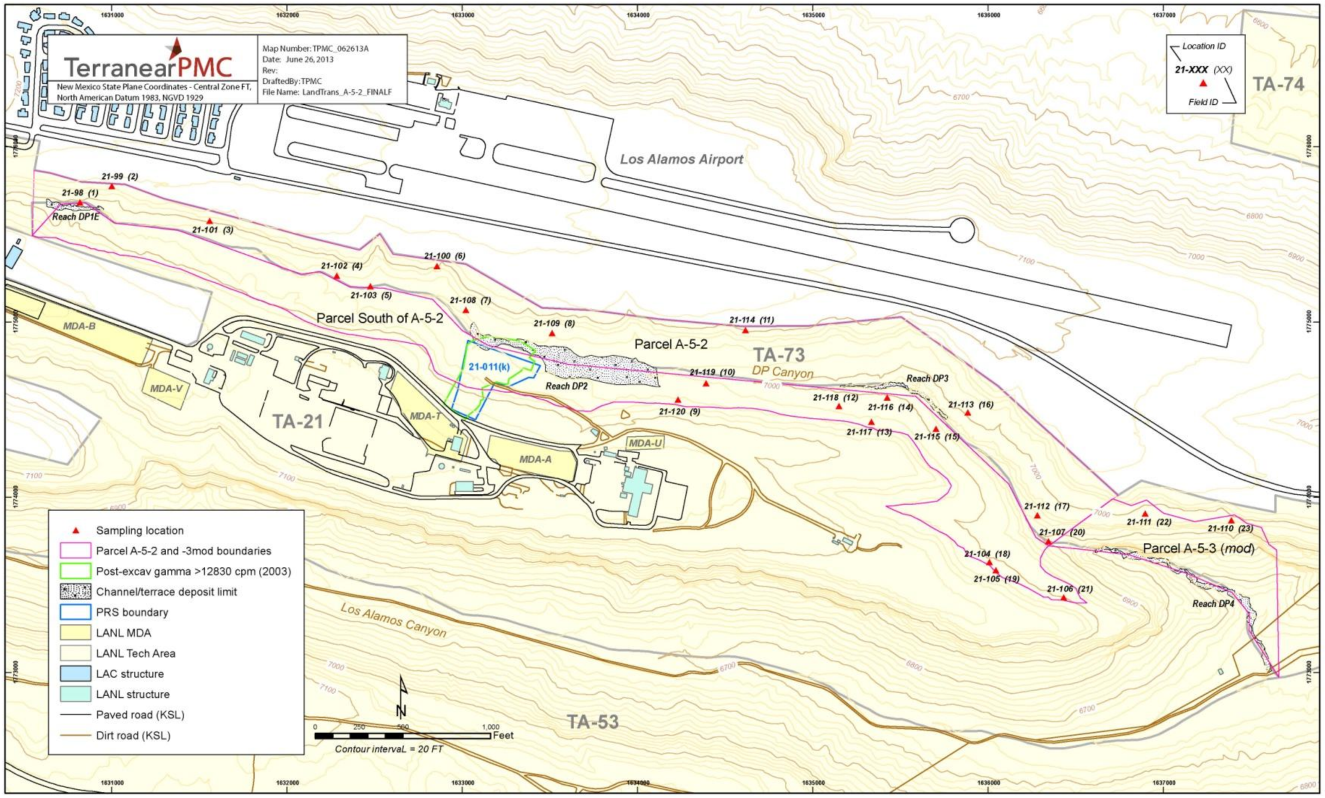


Figure 3. Approximate sampling locations in the northern and southern portions of Tract A-5-3 based on a MARSSIM-like sampling protocol.

Table 1. Preliminary survey results used for MARSSIM-based development of the sampling plan far Tract-A-5-3.

LOCATION_ID	Am-241	Co-60	Cs-137	H-3	Pu-238	Pu-239/240	Sr-90	U-234	U-235	U-238
21-104	0.011	-0.001	0.963	0.805	0.006	0.267	-0.002	0.814	0.016	0.93
21-105	0.162	0.003	0.765	-2.344	0.003	0.194	0.303	0.95	0.028	0.922
21-106	0.026	-0.005	0.166	-2.281	-0.006	0.045	-0.067	0.731	0	0.702
21-107	4.613	0	13.668	-0.869	0.416	2.345	3.817	1.278	0.061	0.813
21-110	0.026	-0.007	0.05	-0.709	0.008	0.025	0.224	0.583	0.026	0.63
21-111	0.27	0.002	0.459	-1.236	0.014	0.037	0.313	0.607	0.015	0.766
21-112	0.018	-0.007	0.202	-0.908	0.005	0.046	0.284	0.64	0.024	0.878
Mean	*0.732*	*-0.002*	*2.325*	*-1.077*	*0.064*	*0.423*	*0.696*	*0.800*	*0.024*	*0.806*
Median	*0.026*	*-0.001*	*0.459*	*-0.908*	*0.006*	*0.046*	*0.284*	*0.731*	*0.024*	*0.813*
SD	*1.714*	*0.004*	*5.013*	*1.067*	*0.155*	*0.853*	*1.385*	*0.247*	*0.019*	*0.114*
BKG	0.013		1.65	0.08	0.023	0.054	1.31	2.59	0.2	2.29
15 mrem/yr residental SAL	*49*	*1.5*	*6.7*	*510*	*50*	*48*	*9*	*160*	*23*	*92*
15 mrem/yr recreational SAL	*890*	*46*	*210*	*430000*	*850*	*770*	*3200*	*2300*	*570*	*1700*

Attachment 1:
Results from MARSSIM Analysis from VSP

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM) for Tract A-5-3 (Northern and Southern portions)

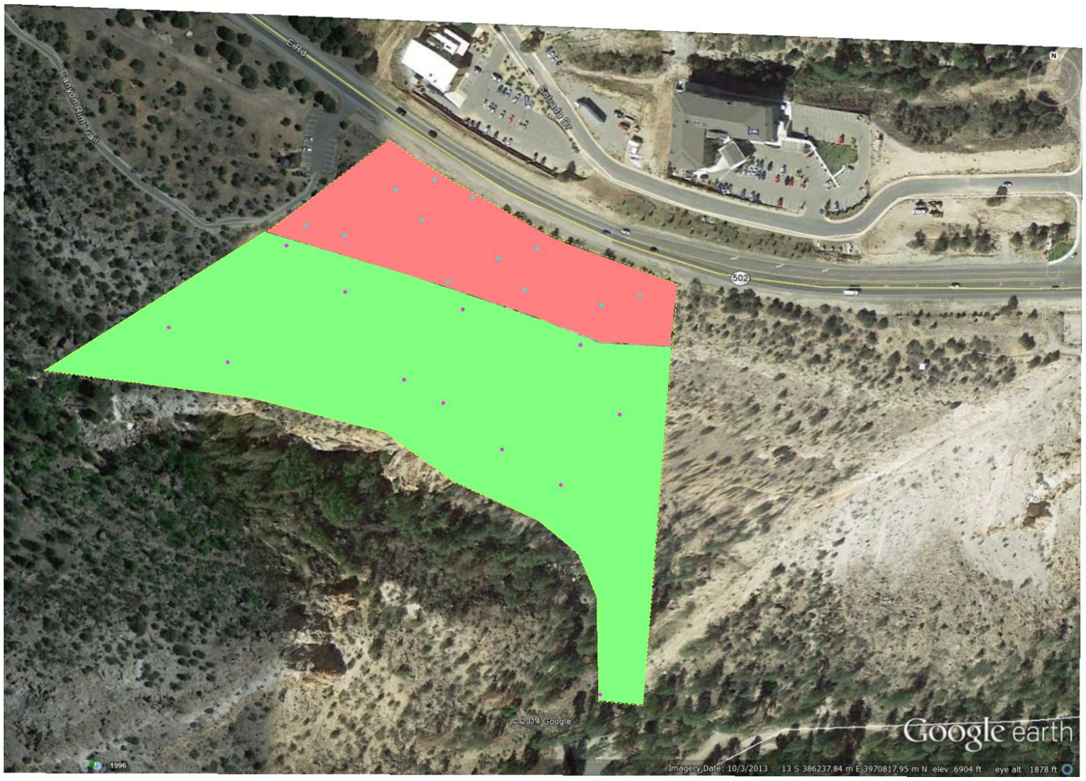
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	12
Number of samples on map [a]	24
Number of selected sample areas [b]	2
Specified sampling area [c]	47949.59 m^2

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.



Area: A-5-3 North					
X Coord	Y Coord	Label	Value	Type	Historical
386193.5872	3970937.3029			Random	
386224.0230	3970882.6212			Random	
386163.1514	3970923.6324			Random	
386208.8051	3970900.8484			Random	
386147.9335	3970941.8597			Random	
386269.6766	3970873.5076			Random	
386117.4978	3970914.5188			Random	
386178.3693	3970887.1780			Random	
386231.6319	3970906.9242			Random	
386170.7604	3970947.9354			Random	
386292.5035	3970879.5834			Random	
386094.6709	3970920.5946			Random	

Area: A-5-3 South					
X Coord	Y Coord	Label	Value	Type	Historical
386175.7466	3970815.2973			Random	
386082.8261	3970908.6480			Random	
386268.6671	3970642.4256			Random	
386152.5165	3970829.1270			Random	
386245.4370	3970766.8932			Random	
386013.1357	3970860.2439			Random	
386047.9809	3970839.4993			Random	
386187.3617	3970870.6162			Random	
386280.2822	3970808.3824			Random	
386257.0521	3970849.8716			Random	

386210.5918	3970787.6378			Random	
386117.6713	3970880.9885			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$	is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n	is the number of samples,
S_{total}	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Am-241	12	1.7 pCi/g	3.4 pCi/g	0.05	0.1	1.64485	1.28155
Cs-137	12	5 pCi/g	10 pCi/g	0.05	0.1	1.64485	1.28155
Pu-238	12	0.155 pCi/g	0.3 pCi/g	0.05	0.1	1.64485	1.28155
Pu-239	11	0.85 pCi/g	769 pCi/g	0.05	0.1	1.64485	1.28155
	0						

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=770		**α=5**		**α=10**		**α=15**	
		s=1.7	**s=0.85**	**s=1.7**	**s=0.85**	**s=1.7**	**s=0.85**
LBGR=90	**β=5**	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=80	**β=5**	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=70	**β=5**	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site median(mean) value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.